ESRF	**Experiment title:** Dynamics and structure of electrorheological chain formation in synthetic nano-layered silicates	**Experiment number:** 01-02-675
Beamline: BM01A	**Date of experiment:** from: 13/07/2003 to: 15/07/2003	**Date of report:** 26/09/2003
Shifts: 6	**Local contact(s):** Dr. Philip Pattison	*Received at ESRF:*

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Scientific background – motivation for the study :

Electrorheological fluids have the property of displaying drastic changes in their rheology when exposed to a sufficiently intense electric field. The simplest form of electrorheological fluid is a suspension of polarizable particules immersed in a non-polar fluid [1]; Dipolar interaction between polarized particles is responsible for their aggregation along chains parallel to the electric field [1]. Nano-layered silicate suspensions, or clay suspensions, on the other hand, are colloidal suspensions of platelets that display a complex phase behavior depending among other things on the concentration in colloids, ionic strength of the solvent, and particle sizes. These properties have been investigated theoretically and experimentally using many techniques [2], among which synchrotron X-ray scattering methods [3, 4].

Microscope observations carried out in our laboratory at NTNU in Trondheim (Norway) on suspensions of fluorohectorite clays showed evidence of an electrorheological behavior for an electric field of a few kV/mm [5]. Fluorohectorites are synthetic swelling clays with a formula X_x-$Mg_{3-x}Li_xSi_4O_{10}F_2$. The colloidal particles consist of a stacking of ~ 100 silicate platelets that are bonded together by an interlayer cation X, the nature of which influences the strength of the bonding and the interaction between particles in the solvent. Cations and water molecules can be intercalated between the platelets, which plays a role in the polarizability of the particles.

In the spring of 2003 we performed WAXS experiments using the 2D MAR detector at BM01A. From this data we determined the orientation of the particles in our electrorheological chains, and showed that they polarize along the nanosilicate sheets [5]. The series of WAXS presently reported addressed the dynamics of the chain formation: we observed ordering within the chains as a function of time after application of the field. We also investigated how this dynamics depends on the nature of the intercalated ions and on the quantity of water intercalated together with the ions.

Experimental method:

The three types of samples consisted of fluorohectorite (X=Na, Ni and Fe) particles immersed in a silicone oil (viscosity 100 cSt).

They were investigated by Wide Angle X-Ray Scattering, using a wavelength $\lambda = 0.71$ Å.

A cell that we specially designed allows to apply a high voltage E between 2 copper electrodes, between which the sample is contained. This cell is a development of that used last year. Its electrically-insulating parts are in teflon so that the cell be able to bear temperatures up to 200 degrees. At controlled temperature, an electric field ~ 1 kV/mm was applied between the electrodes, after which a series of 2D diffractograms was recorded until the system was observed to be stabilized in its electorheological "organized" state. This was repeated for the three types of clays under different hydration states. The 6 shifts of beam time awarded were fully utilized. More time would have been needed in order to perform experiments at different magnitudes of the electric field.

Results obtained:

The analysis method is basically the same as that described in a previous report (experiment 01-02-634; see also [5]). The analyses carried out up to now have demonstrated that the number of intercalated water layers does not seem to have a strong influence on the characteristic time for the electrorheological phenomenon, while the nature of the intercalated ion is more important (see Fig. 1). On the one hand, these first analyzes have allowed us to finish the discussion of an article based on the previous set of experiments (spring 2003), regarding the main controlling factors for the polarization of clay particles [5]. Extensive data treatment is ongoing in order to obtain broader and more quantitative results.

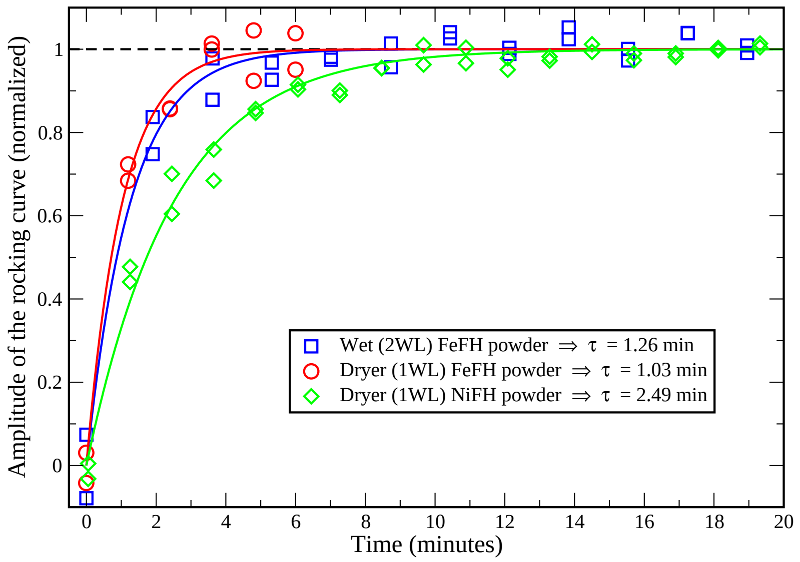

Fig. 1 – Time-evolution of the width of the angular distribution of clay particles inside the electrorheological chains, for two types of intercalated ions and different hydration states.

References

[1] Tian Hao. Electrorheological fluids. *Adv. Mater.*, 13:1847, 2001.

[2] J. O. Fossum. Physical phenomena in clays. *Physica A*, 270(1-2), 1999.

[3] E. DiMasi, J. O. Fossum, T. Gog, and C. Venkataraman. Orientational order in gravity dispersed clay colloids: A synchrotron X-ray scattering study of Na fluorohectorite suspensions. *Phys. Rev. E*, 64:061704, 2001.

[4] G. J. da Silva, J. O. Fossum, and E DiMasi. Synchrotron X-ray scattering studies of water intercalation in a layered synthetic silicate. *Phys. Rev. E*, 66(1):011303, 2002.

[5] J. O. Fossum, Y. Méheust, K. S. Parmar, D. M. de Miranda Fonseca, K. D. Knudsen, and K.-J. Måløy. Dipolar chain formation and particle orientational ordering in oil suspensions of nano-layered clay particles. Preprint.